

IT IS CLAIMED:

- 1 1. An ultrasonic etching apparatus for chemically-etching a workpiece, said
2 apparatus comprising
3 an outer tank at least partially filled with an aqueous solution;
4 an inner tank comprising a chemically-resistant polymer and at least partially
5 disposed within said outer tank and in contact with said aqueous solution, said inner
6 tank at least partially filled with at least 1 liter of an etching solution having a total
7 acidity or basicity of at least 10% wt, said inner tank having at least a sidewall and a
8 base and defining an upper mouth, and being receptive to the workpiece;
9 a lid engaged with said mouth of said inner tank, wherein the weight of the
10 lid creates at least a partial seal between the mouth of said inner tank and a lower
11 surface of said lid to increase the partial pressure of the gas above the etching
12 solution; and
13 an ultrasonic transducer coupled to said outer tank to impart ultrasonic
14 energy to said etching solution in said inner tank.
- 1 2. The apparatus of claim 1, further comprising a heating element for
2 regulating the temperature of the aqueous solution.
- 1 3. The apparatus of claim 1, further comprising a mechanism adapted to
2 impart relative motion between the workpiece disposed in said inner tank and said
3 ultrasonic transducer.
- 1 4. The apparatus of claim 3, wherein the mechanism comprises a rod
2 extending through the lid and coupled to the workpiece.
- 1 5. The apparatus of claim 1, further comprising an exhaust hood which is
2 located above the tanks and compatible with gases produced from at least one of
3 the aqueous solution and the etching solution.
- 1 6. The apparatus of claim 1, further comprising an ultrasonic buffer
2 positioned within the aqueous solution for dampening and/or diffusing the sonic
3 energy imparted to the etching solution.
- 1 7. The apparatus of claim 1, wherein the ultrasonic transducer is positioned
2 outside of the aqueous solution and is operably connected to a power oscillator.
- 1 8. The apparatus of claim 1, further comprising a probe positioned within

2 the etching solution for monitoring one or more of the ultrasonic energy,
3 temperature, temperature variations and impurity concentration.

1 9. The apparatus of claim 1, wherein the aqueous solution is a filtered and
2 recirculated deionized water bath.

1 10. The apparatus of claim 1, wherein the etching solution is essentially
2 static.

1 11. The apparatus of claim 1, wherein the inner tank and any portion of the
2 rotational mechanism that may come into contact with the etching solution
3 comprises a material selected from the group consisting of a fluorine resin and high
4 density polyethylene.

1 12. The apparatus of claim 11, wherein the inner tank generates less than
2 10 ppb of leachable metal contaminants and 10 ppm of leachable anionic and
3 organic contaminants.

1 13. The apparatus of claim 1, wherein the etching solution comprises an
2 acid selected from the group consisting of hydrofluoric acid, nitric acid and
3 hydrochloric acid.

1 14. The apparatus of claim 13, wherein the acidic solution comprises
2 hydrofluoric acid, nitric acid and water in a ratio selected from the group consisting
3 of 1:1:1, 1:2:2 and 1:7:4.

1 15. The apparatus of claim 1, wherein the temperature of the aqueous
2 solution is maintained from about 20°C to about 50°C.

1 16. The apparatus of claim 1, wherein the workpiece is selected from the
2 group consisting of silicon carbide, quartz, ceramic and silicon.

1 17. The apparatus of claim 3, wherein the mechanism comprises a rotary
2 motion actuator for rotating said substrate about an axis.

1 18. The apparatus of claim 17, wherein the axis is a substantially horizontal
2 axis.

1 19. The apparatus of claim 17, wherein the axis is a substantially vertical
2 axis.

1 20. The apparatus of claim 3, wherein the mechanism comprises a rotary
2 motion actuator for rotating said inner tank and/or said ultrasonic transducer.

1 21. The apparatus of claim 1, wherein the cross-section of the lid is
2 substantially the same as the cross section of the mouth of the inner tank.

1 22. The apparatus of claim 21, wherein the mouth of the inner tank and the
2 lid each have a circular shape corresponding to the cross-section of the lid.

1 23. The apparatus of claim 1, wherein the cross-section of the inner tank is
2 substantially the same as the cross section of the workpiece.

1 24. The apparatus of claim 1, wherein the mouth of the inner tank has a
2 shape selected from the group consisting of a square, rectangle, triangle, circle and
3 oval.

1 25. The apparatus of claim 1, wherein the inner tank has a shape selected
2 from the group consisting of a rectangular parallelepiped, cube and cylinder.

1 26. The apparatus of claim 1, wherein the etching solution comprises a
2 base selected from the group consisting of sodium hydroxide and potassium
3 hydroxide.

1 27. The apparatus of claim 26, wherein the etching solution comprises 30%
2 potassium hydroxide.

1 28. A method for ultrasonically chemically-etching a workpiece, said
2 method comprising
3 providing an inner tank having an inner surface comprising a chemically-
4 resistant polymer and defining an upper mouth and being receptive to the
5 workpiece, wherein said inner tank is at least partially disposed within an outer tank
6 at least partially filled with an aqueous solution;
7 at least partially filling the inner tank with at least 1 liter of a etching solution
8 having a total acidity or basicity of at least 10%;
9 immersing the workpiece into the etching solution;
10 covering the mouth of the inner tank with a lid to enclose the etching
11 solution and to increase the partial pressure above the etching solution; and
12 ultrasonically agitating the etching solution with an ultrasonic transducer

13 coupled to the outer tank to accelerate the etching of the workpiece.